

What is claimed is:

1. A protecting apparatus for protecting a main transistor formed on a semiconductor substrate from a rapid surge, comprising:

5 a back-flow preventing Zener diode having a cathode connected directly to a control terminal of said main transistor for preventing current from flowing in a predetermined direction;

a protecting transistor having an output terminal connected to an anode of said back-flow preventing Zener diode and an input terminal connected to an input terminal of said main transistor; and

10 a protecting capacitor connected between a control terminal of said protecting transistor and the input terminal of said main transistor for allowing initial surge current, when caused based on a rapid surge, to flow into the control terminal of said protecting transistor,

15 wherein

said protecting transistor, when turning on in response to said initial surge current, allows next surge current succeeding said initial surge current to flow into the control terminal of said main transistor via said back-flow preventing Zener diode, and

20 said main transistor, when turning on in response to said next surge current, allows late surge current succeeding said next surge current to flow therethrough.

25 2. The protecting apparatus for a semiconductor device in accordance with claim 1, wherein said main transistor and said protecting transistor are metal oxide semiconductor field-effect transistors.

30 3. The protecting apparatus for a semiconductor device in accordance with claim 1, wherein an auxiliary protecting transistor is connected between said protecting transistor and said protecting capacitor for amplifying said initial surge current and supplying the amplified initial surge current to the control terminal

of said protecting transistor.

4. The protecting apparatus for a semiconductor device in accordance with claim 3, wherein all of said main transistor, said protecting transistor, and said auxiliary protecting transistor are metal oxide semiconductor field-effect transistors.

5. The protecting apparatus for a semiconductor device in accordance with claim 3, wherein said protecting transistor includes a built-in transistor.

6. The protecting apparatus for a semiconductor device in accordance with claim 5, wherein said main transistor is a metal oxide semiconductor field-effect transistor and said protecting transistor and said auxiliary protecting transistor are bipolar transistors.

7. The protecting apparatus for a semiconductor device in accordance with claim 1, wherein

a protecting Zener diode is connected in parallel with said protecting capacitor,

a first initial surge current flows through said protecting capacitor, and a second initial surge current, succeeding said first initial surge current, flows through said protecting Zener diode.

8. The protecting apparatus for a semiconductor device in accordance with claim 1, further comprising:

a protecting Zener diode connected in parallel with said protecting transistor, said protecting Zener diode having a cathode connected to the input terminal of said main transistor and an anode connected to the anode of said back-flow preventing Zener diode;

wherein said main transistor controls current supplied to a load connected to the input terminal of said main transistor, said load generates a load surge

when the current supply is stopped, said rapid surge is caused by an electrostatic discharge, said load surge is small in frequency than said rapid surge, and said protecting Zener diode causes breakdown in response to said load surge so as to turn on said main transistor prior to a turning-on operation of said protecting transistor by said protecting capacitor.

9. The protecting apparatus for a semiconductor device in accordance with claim 8, wherein said rapid surge has a frequency in the range of GHz, and said load surge has a frequency in the range of kHz.

10. The protecting apparatus for a semiconductor device in accordance with claim 1, wherein

a relationship  $R_d > R_h$  is satisfied

where  $R_h$  represents an operation resistance in a flowing path of said next surge current flowing into the control terminal of said main transistor via said back-flow preventing Zener diode, and

$R_d$  represents an actuating resistance disposed in a path connected to an actuating circuit for actuating said main transistor.

11. The protecting apparatus for a semiconductor device in accordance with claim 8, wherein

a relationship  $R_d > R_h$  is satisfied

where  $R_h$  represents an operation resistance in a flowing path of a load surge current flowing into the control terminal of said main transistor via said back-flow preventing Zener diode, and

$R_d$  represents an actuating resistance disposed in a path connected to an actuating circuit for actuating said main transistor.

12. The protecting apparatus for a semiconductor device in accordance with claim 1, wherein

said main transistor is formed as a cell region including a plurality of

single cells on said semiconductor substrate,

said control terminal of said main transistor is formed as a common electrode of said plurality of single cells,

said control terminal of said main transistor extends out of said cell region,

5 a signal applying electrode is connected to said control terminal of said main transistor, said signal applying electrode being formed on a surface of said semiconductor substrate so as to surround said cell region,

10 said signal applying electrode is connected to the cathode of said back-flow preventing Zener diode, and a wiring width of said signal applying electrode is wider than a wiring width of a lead connecting said cathode of said back-flow preventing Zener diode to said signal applying electrode.

13. A protecting apparatus for protecting a main transistor formed on a semiconductor substrate from a rapid surge, comprising:

15 a back-flow preventing Zener diode having a cathode connected to a control terminal of said main transistor for preventing current from flowing in a predetermined direction;

20 a protecting Zener diode having an anode connected to an anode of said back-flow preventing Zener diode and a cathode connected to an input terminal of said main transistor; and

a protecting capacitor connected in parallel with said protecting Zener diode for allowing initial surge current, when caused based on a rapid surge, to flow into the control terminal of said main transistor via said back-flow preventing Zener diode,

25 wherein said protecting Zener diode allows next surge current succeeding said initial surge current to flow into the control terminal of said main transistor via said back-flow preventing Zener diode, and

30 said main transistor, when turning on in response to said initial surge current or said next surge current, allows late surge current succeeding said next surge current to flow therethrough.

14. A protecting apparatus for protecting a main transistor formed on a semiconductor substrate from a rapid surge, comprising:

a protecting transistor having an output terminal connected to a control terminal of said main transistor and an input terminal connected to an input terminal of said main transistor, said protecting transistor comprising a built-in back-flow preventing Zener diode; and

a protecting capacitor connected between a control terminal of said protecting transistor and the input terminal of said main transistor for allowing initial surge current, when caused based on a rapid surge, to flow into the control terminal of said protecting transistor,

wherein

said protecting transistor, when turning on in response to said initial surge current, allows next surge current succeeding said initial surge current to flow into the control terminal of said main transistor, and

said main transistor, when turning on in response to said next surge current, allows late surge current succeeding said next surge current to flow therethrough.

15. The protecting apparatus for a semiconductor device in accordance with claim 14, wherein said main transistor is a metal oxide semiconductor field-effect transistor and said protecting transistor is a bipolar transistor.

16. The protecting apparatus for a semiconductor device in accordance with claim 14, wherein an auxiliary protecting transistor is connected between said protecting transistor and said protecting capacitor for amplifying said initial surge current and supplying the amplified initial surge current to the control terminal of said protecting transistor.

17. A protecting apparatus for protecting a main transistor formed on a semiconductor substrate from a rapid surge, comprising:

a back-flow preventing Zener diode having a cathode connected to a

control terminal of said main transistor for preventing current from flowing in a predetermined direction; and

a protecting transistor circuit including a plurality of transistors consisting of an initial transistor and at least one succeeding transistor connected in a Darlington connecting pattern, each transistor having an output terminal connected to an anode of said back-flow preventing Zener diode and an input terminal connected to an input terminal of said main transistor,

wherein said protecting transistor circuit turns on said succeeding transistor in response to initial surge current caused based on a rapid surge, and further turns on said initial transistor in response to the turning of said succeeding transistor,

said initial transistor, when turning on, allows next surge current succeeding said initial surge current to flow into the control terminal of said main transistor, and

said main transistor, when turning on in response to said next surge current, allows late surge current succeeding said next surge current to flow therethrough.

18. The protecting apparatus for a semiconductor device in accordance with claim 17, wherein said main transistor and each transistor in said protecting transistor circuit are metal oxide semiconductor field-effect transistors.

19. A protecting apparatus for protecting a main transistor formed on a semiconductor substrate from a rapid surge, comprising:

a back-flow preventing Zener diode having a cathode connected directly to a control terminal of said main transistor for preventing current from flowing in a predetermined direction;

a protecting transistor having an output terminal connected to an anode of said back-flow preventing Zener diode and an input terminal connected to an input terminal of said main transistor; and

a Zener diode circuit connected between a control terminal of said

protecting transistor and the input terminal of said main transistor for allowing initial surge current, when caused based on a rapid surge, to flow into the control terminal of said protecting transistor,

wherein

5        said protecting transistor, when turning on in response to said initial surge current, allows next surge current succeeding said initial surge current to flow into the control terminal of said main transistor via said back-flow preventing Zener diode, and

10        said main transistor, when turning on in response to said next surge current, allows late surge current succeeding said next surge current to flow therethrough.

15        20. The protecting apparatus for a semiconductor device in accordance with claim 19, wherein said main transistor and said protecting transistor are metal oxide semiconductor field-effect transistors.

20        21. The protecting apparatus for a semiconductor device in accordance with claim 19, wherein an auxiliary protecting transistor is connected between said protecting transistor and said Zener diode circuit for amplifying said initial surge current and supplying the amplified initial surge current to the control terminal of said protecting transistor.

25        22. The protecting apparatus for a semiconductor device in accordance with claim 21, wherein all of said main transistor, said protecting transistor, and said auxiliary protecting transistor are metal oxide semiconductor field-effect transistors.

30        23. The protecting apparatus for a semiconductor device in accordance with claim 21, wherein said protecting transistor includes a built-in transistor.

24. The protecting apparatus for a semiconductor device in accordance

with claim 23, wherein said main transistor is a metal oxide semiconductor field-effect transistor and said protecting transistor and said auxiliary protecting transistor are bipolar transistors.

5           25. A protecting apparatus for protecting a main transistor formed on a semiconductor substrate from a rapid surge, comprising:

          a protecting transistor having an output terminal connected to a control terminal of said main transistor and an input terminal connected to an input terminal of said main transistor, said protecting transistor comprising a built-in  
10       back-flow preventing Zener diode; and

          a Zener diode circuit connected between a control terminal of said protecting transistor and the input terminal of said main transistor for allowing initial surge current, when caused based on a rapid surge, to flow into the control terminal of said protecting transistor,

15       wherein

          said protecting transistor, when turning on in response to said initial surge current, allows next surge current succeeding said initial surge current to flow into the control terminal of said main transistor, and

20       said main transistor, when turning on in response to said next surge current, allows late surge current succeeding said next surge current to flow therethrough.

26. The protecting apparatus for a semiconductor device in accordance with claim 25, wherein said main transistor is a metal oxide semiconductor field-effect transistor and said protecting transistor is a bipolar transistor.  
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27. The protecting apparatus for a semiconductor device in accordance with claim 25, wherein an auxiliary protecting transistor is connected between said protecting transistor and said Zener diode circuit for amplifying said initial  
30       surge current and supplying the amplified initial surge current to the control terminal of said protecting transistor.



28. The protecting apparatus for a semiconductor device in accordance with any one of claims 1, 13, 14, 17, 19 and 25, wherein

a wiring member, serving as a parasitic inductance against the applied surge, is connected between the input terminal of said main transistor and a load, and said wiring member is provided outside a chip accommodating said main transistor.

29. A semiconductor device comprising:

an insulated gate transistor disposed in a current path of an electric load;

a gate voltage boosting element having one end connected to a gate electrode of said insulated gate transistor so as to operate in response to a surge applied from a high-voltage terminal of said insulated gate transistor;

a wiring member serving as a parasitic inductance against the applied surge, said wiring member being connected in parallel with said gate voltage boosting element with respect to the high-voltage terminal of said insulated gate transistor,

wherein said insulated gate transistor and said gate voltage boosting element are formed in a chip, and said wiring member is provided outside said chip.

30. The semiconductor device in accordance with claim 29, wherein said wiring member is a bonding wire.

31. The semiconductor device in accordance with claim 29, wherein said chip is a resin molded chip mounted on a printed circuit board, and said wiring member is a combination of a bonding wire, a lead frame, and a conductive pattern formed on said printed circuit board.

32. The semiconductor device in accordance with claim 29, wherein said chip is mounted on a semiconductor substrate by using the flip chip

bonding method, and

said wiring member is a conductive pattern formed on said semiconductor substrate.

5           33. The semiconductor device in accordance with claim 29, wherein said gate voltage boosting element is a Zener diode.

10           34. The semiconductor device in accordance with claim 29, wherein said gate voltage boosting element is a combination of a plurality of circuit elements selected from the group consisting of a Zener diode, a bipolar transistor, and a metal oxide semiconductor transistor.

15           35. The semiconductor device in accordance with claim 29, wherein said gate voltage boosting element is a combination of a plurality of circuit elements selected from the group consisting of a capacitor, a bipolar transistor, and a metal oxide semiconductor transistor.

20           36. The semiconductor device in accordance with claim 29, wherein said gate voltage boosting element is a set of a capacitor and a Zener diode.